Microgravity, Demonstrations, STEM, and your Classroom

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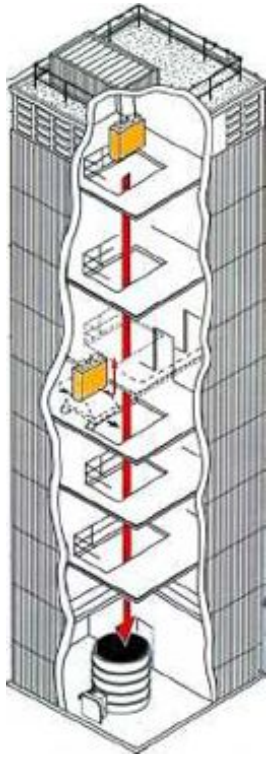
Contents

- Microgravity Mini-tutorial
- Microgravity Demonstration Devices
  - Operate a device & analyze observations
  - Record forces & motions on drawing
  - Repeat with other devices
- Discuss and Share
- DIME and WING Student Competitions

Microgravity Mini-tutorial

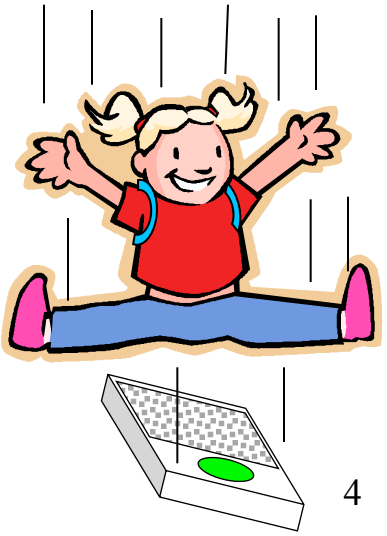
- At NASA Glenn in Cleveland, Ohio we drop things like experiments and test equipment.
- There are two drop towers at NASA Glenn.
  - Zero Gravity Research Facility is a 5 second drop tower.
  - 2.2 Second Drop Tower is a 2.2 second drop tower.
    - For years, it was the world's busiest microgravity facility.
- Experiments are in microgravity conditions during the fall.
- In this session, you'll drop stuff too.
- We'll investigate what happens when things fall.
- But first, what is microgravity?



2.2 Second Drop Tower at NASA Glenn Research Center

Microgravity ≠ Zero Gravity

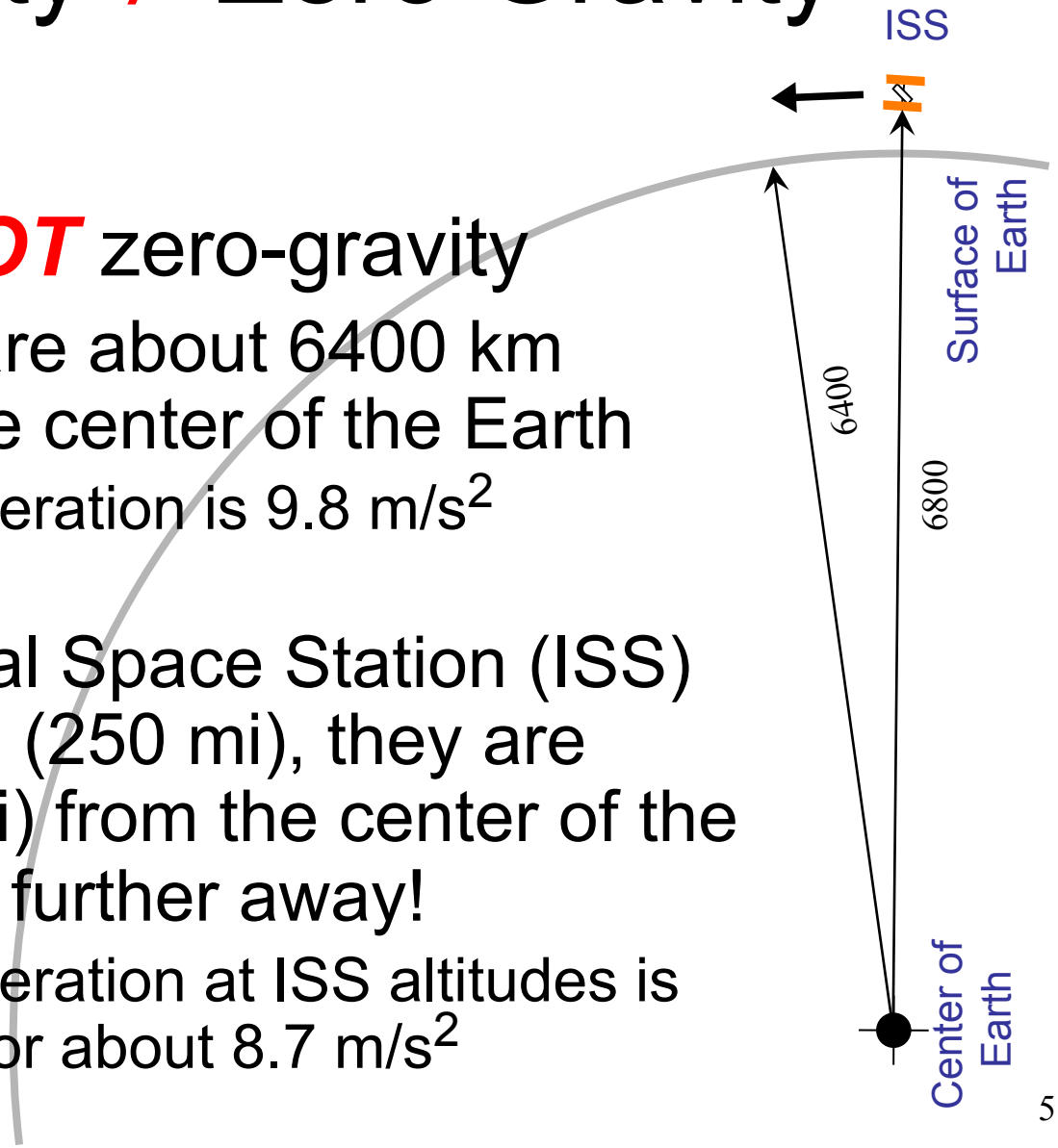
- Microgravity is due to a free-fall condition
  - Gravitational ***effects*** are due to restraining forces which stop an item from falling
    - The floor stops you from falling by exerting a force on your feet.
    - A bathroom scale shows this force as your weight.
  - In free-fall, restraining forces are drastically reduced
    - Everything is falling at the same rate.
    - A person falling with a bathroom scale would not 'weigh' anything as they fall.



(She <u>is</u> wearing a parachute for safety.)

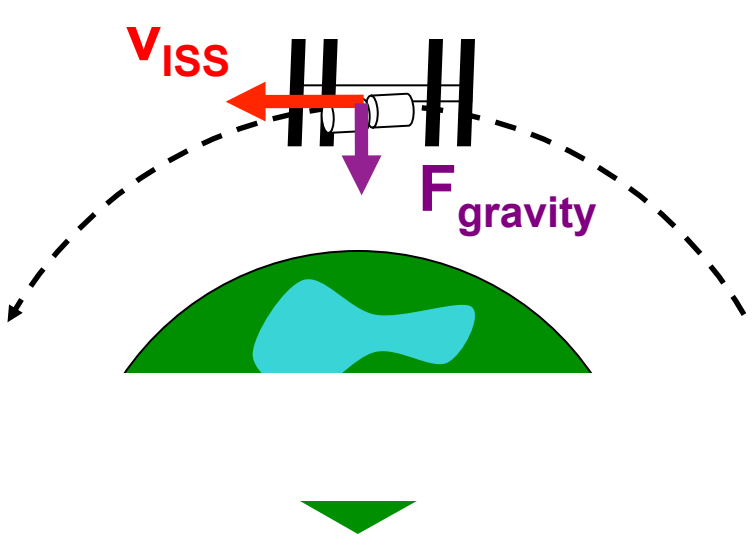
Microgravity ≠ Zero Gravity

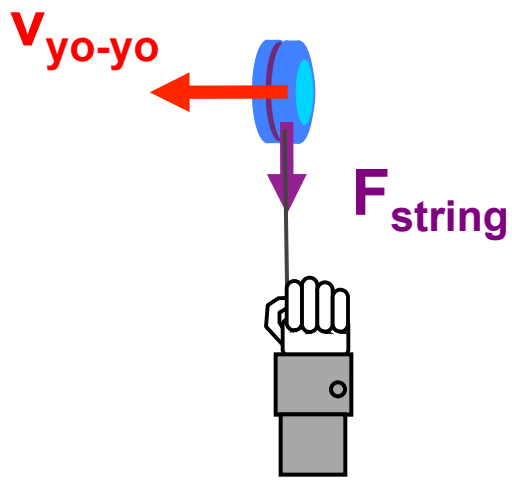
- Microgravity is ***NOT*** zero-gravity
  - At sea-level, we are about 6400 km (4000 mi) from the center of the Earth
    - gravitational acceleration is 9.8 m/s^2 (a.k.a. 1 g)
  - At the International Space Station (ISS) altitude of 400 km (250 mi), they are 6800 km (4250 mi) from the center of the Earth - just a little further away!
    - gravitational acceleration at ISS altitudes is about 88% of 1 g or about 8.7 m/s^2



Microgravity ≠ Zero Gravity

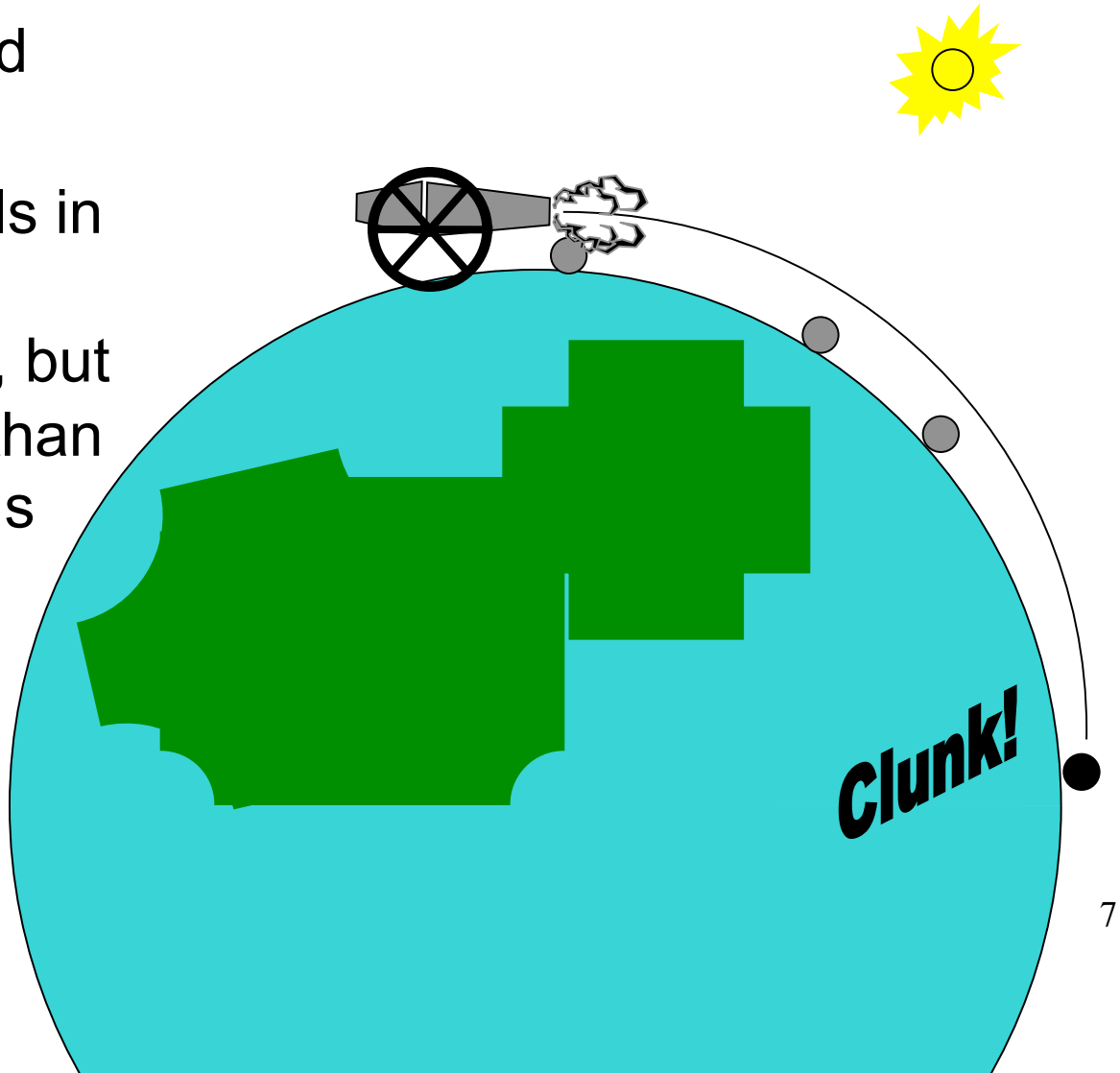
- Microgravity is ***NOT*** a balance of forces
  - The gravitational force acts on the ISS and its contents to maintain a circular orbit
    - Like swinging a yo-yo around in a circle
    - String acts as gravity
  - If there was a net force of zero, the ISS would sail off into space!
    - As the yo-yo does when you let go of the string
    - In classroom, demonstrate with a foam ball on a string





Falling Sideways

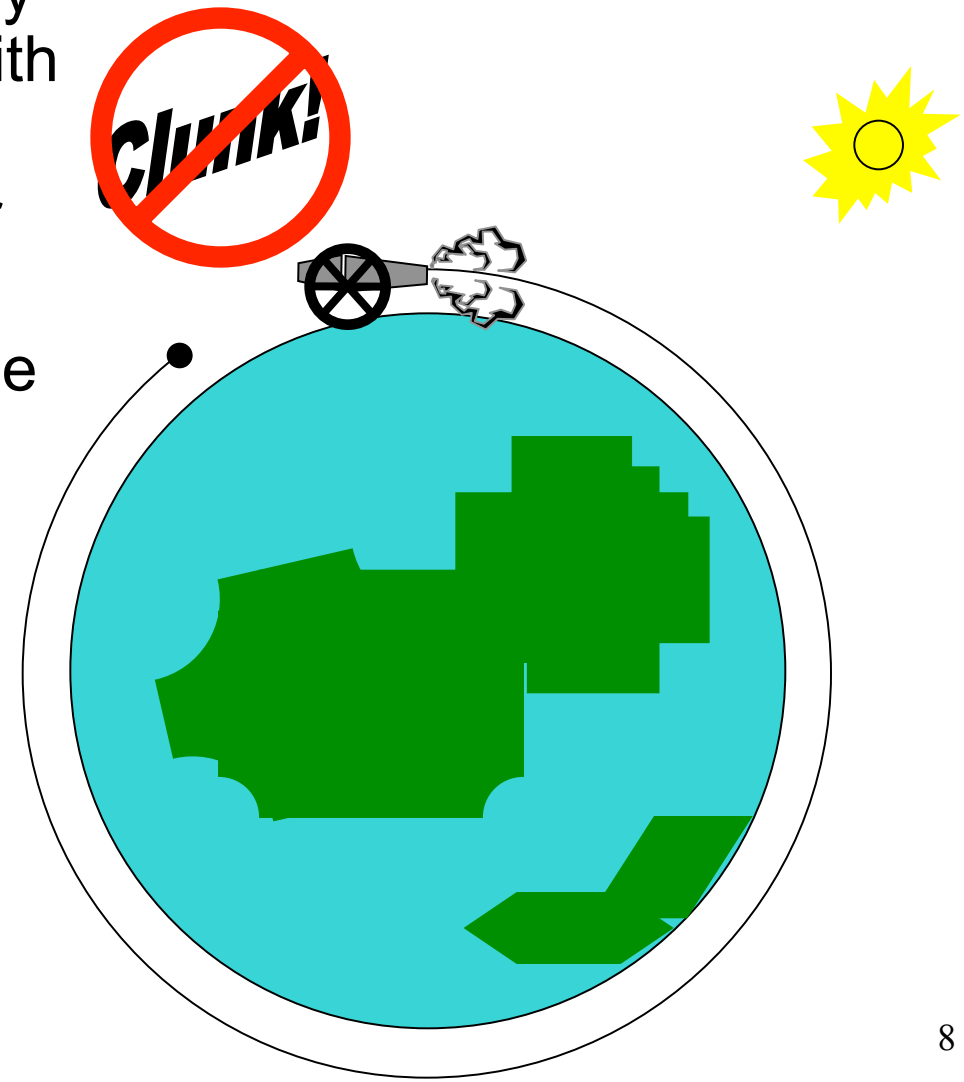
- Cannonballs shot horizontally, faster and faster, go further and further
- Each cannonball falls in a curve toward the Earth due to gravity, but with less curvature than previous cannonballs



Falling with Style

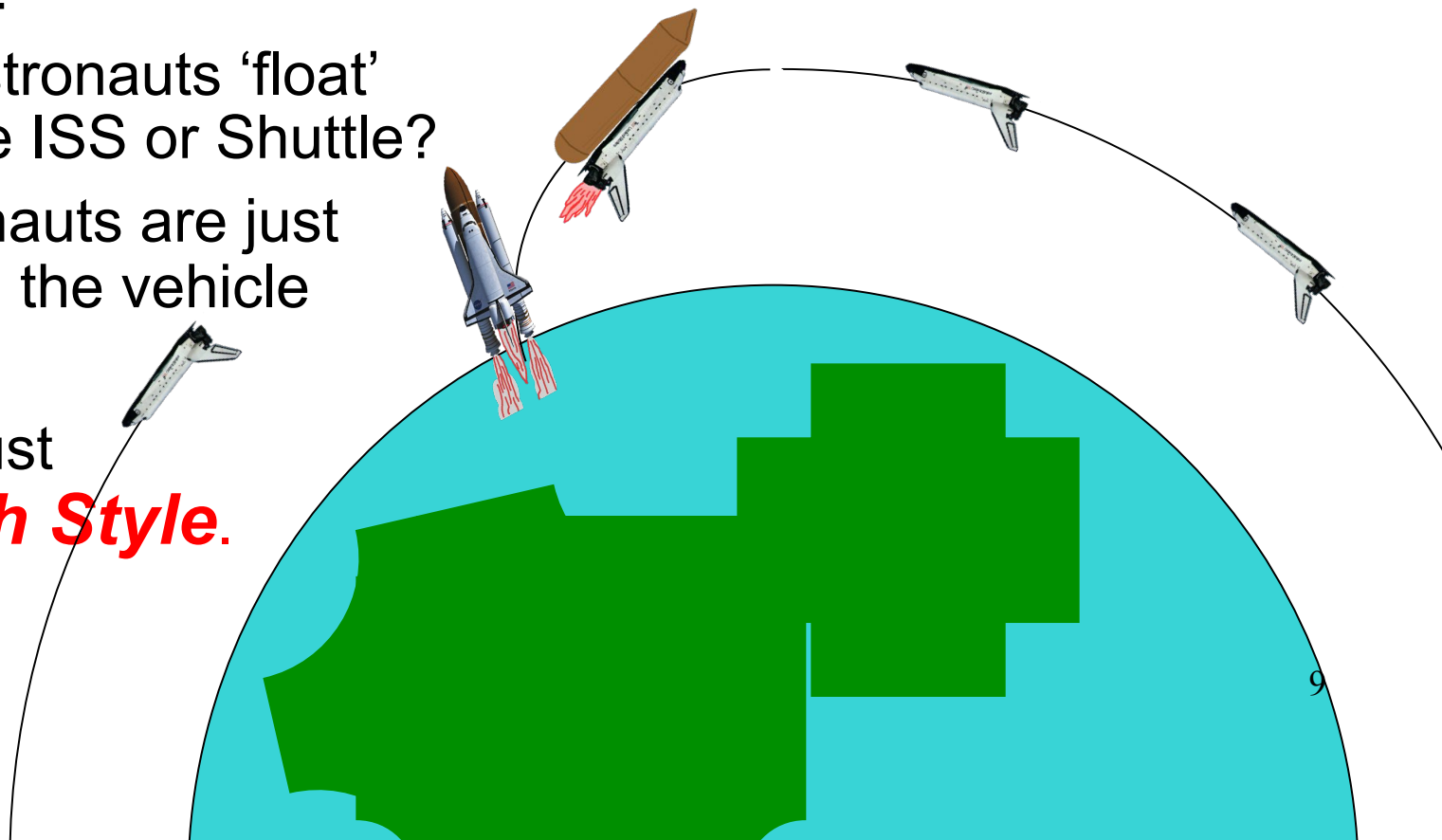
A cannonball shot horizontally at just the right speed falls with the curvature of the Earth

- Speed is about 30,000 km/hr (18,000 mph)
- It curves toward the Earth due to gravity, but so gradually, it falls around the Earth
- Voila, ORBIT!
- It is really just ***Falling with Style***.



Launching with Style

- Shuttle takes off vertically
- As it climbs, it gradually arcs over and develops the proper orbital speed sideways
- When the engines stop, the Shuttle is falling with the curvature of the Earth, just like the cannonball!
- Voila, ORBIT!
- So why do astronauts 'float' around on the ISS or Shuttle?
  - The astronauts are just falling with the vehicle
- This is also just ***Falling with Style***.



Falling Straight Down and Falling with Style

- Conceptually the same - accelerating toward the center of the Earth
- Horizontal velocity is the difference
  - Orbital horizontal speed is about 30,000 km/hr (18,000 mph)
  - Drop tower horizontal speed is 0 km/hr (0 mph)
- So, drop towers can provide free fall (a.k.a. microgravity conditions) just as ISS does

- ***Falling with style*** may be demonstrated in your classroom by dropping a foam ball straight down and then throwing it sideways faster and faster, like the cannonball, and imagine throwing it at 30,000 kph.

Where can you find microgravity?

- Microgravity exists …

… en route to the moon while coasting.

… in orbit on the ISS and Shuttle.

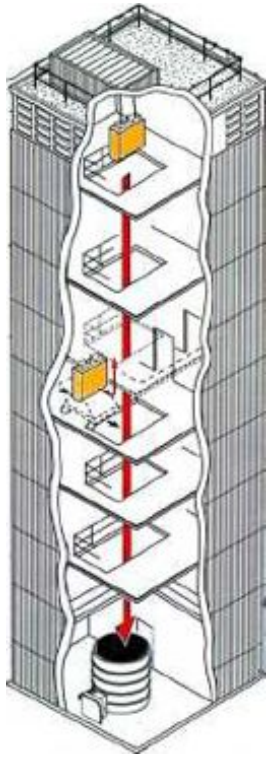
… in sounding rockets (into space).

… in an airplane flying a parabolic path.

… in drop towers.

… in this SEEC session.

… in your classroom.



2.2 Second Drop Tower at NASA Glenn Research Center

NASA Glenn Drop Towers

2.2 Second Drop Tower
(looking down during drop)

Zero Gravity Research Facility
(looking up during capsule recovery)


Questions?
Comments?
Let's explore microgravity!
Hands-on time!

Microgravity Demonstration Devices

- Foam ball
- Foam-rocket launcher
- Feather and cup
- Leaky water bottle
- Astronaut in a bottle
- Magnet shish-ka-bob
- Balloon popper
- Capillary tube in mini drop tower
- Candle flame in mini drop tower

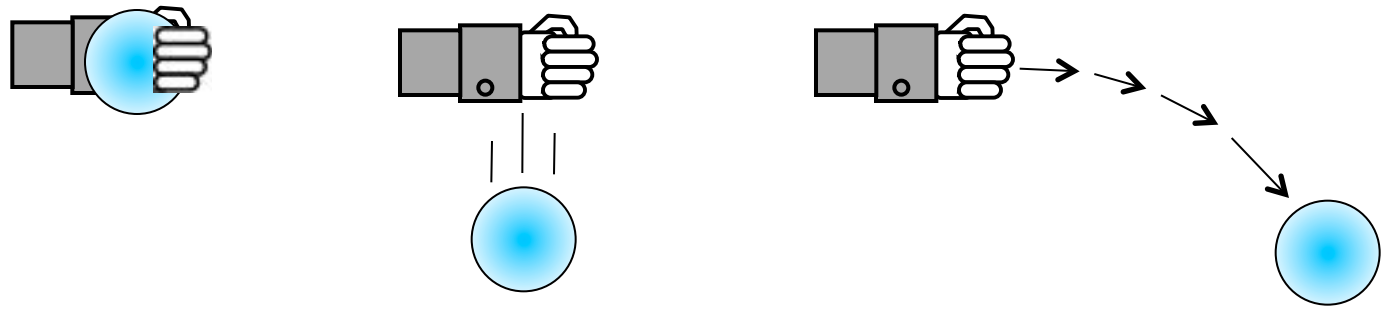
Investigate

- Form small teams.
- Pick a device to drop, many times if necessary.
- Record and analyze what you observe.
- Draw forces and motions on the papers.
- Why does it do what it does?
- Discuss within team and, if needed, with a session leader.
- Repeat process with other devices.
- In general, what is happening when you drop something and it falls? Does gravity really get turned off?

Foam Ball or Foam Rocket Launcher

- Release the ball to fall straight down.
- Then, toss the ball gently horizontally.
- Throw the ball a little faster horizontally.
- Throw it horizontally (SAFELY!) as fast as you can.

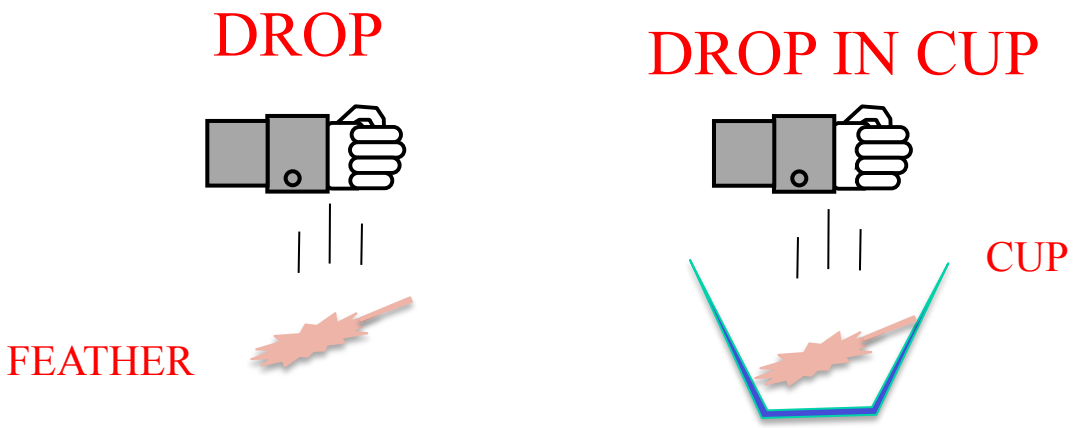
HOLD DROP THROW



WHAT PATH DOES IT FOLLOW? WHAT FORCES ARE THERE?

Feather and Cup

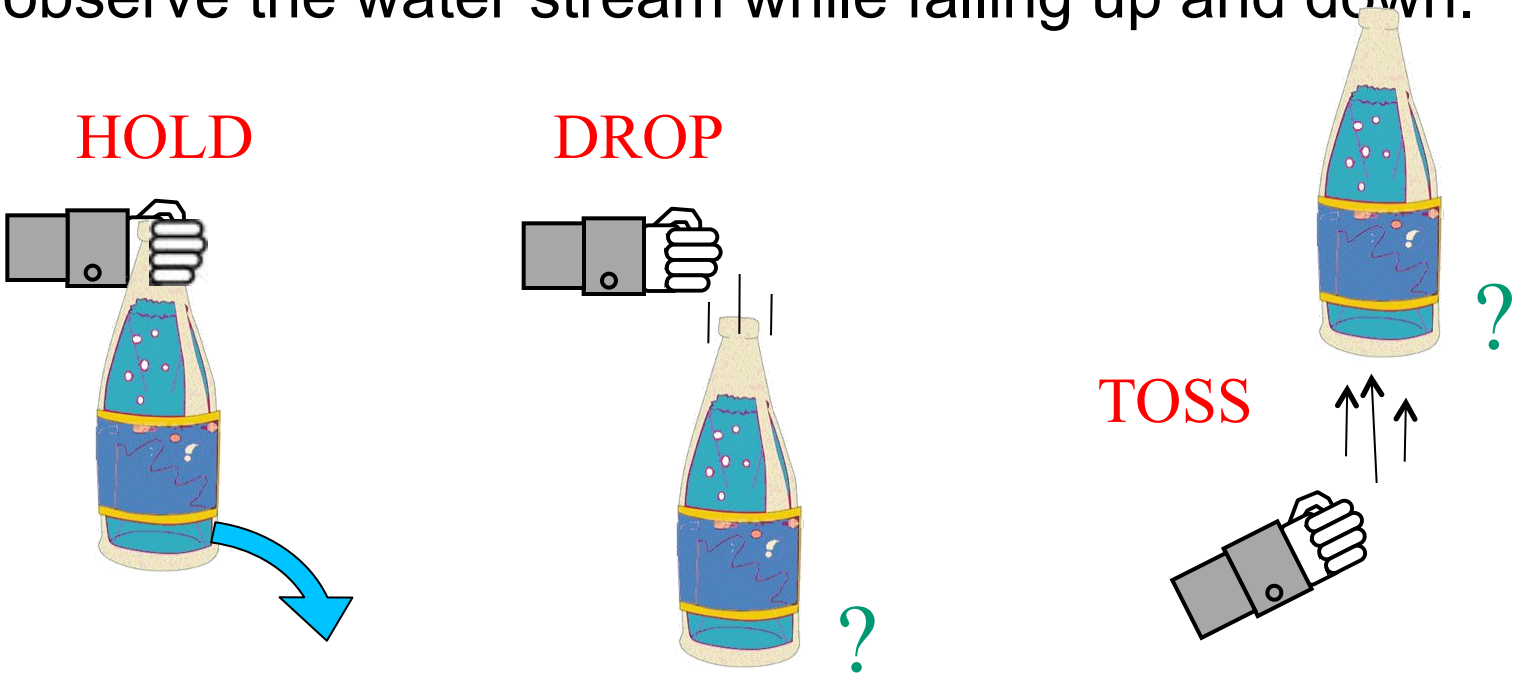
- Drop the feather to fall straight down.
- Then, place the feather in the cup and drop it.
- What does the feather do in each case? Why is it different?
- What forces are acting on the feather?



HOW FAST DOES THE FEATHER FALL?

Leaky water bottle

- Observe the water & stream when bottle is held.
- Release the bottle to fall into the bucket and observe the water stream while falling.
- Toss the bottle straight up (don't spin or tumble) and observe the water stream while falling up and down.



WHAT DOES THE WATER DO? WHAT FORCES ARE THERE?

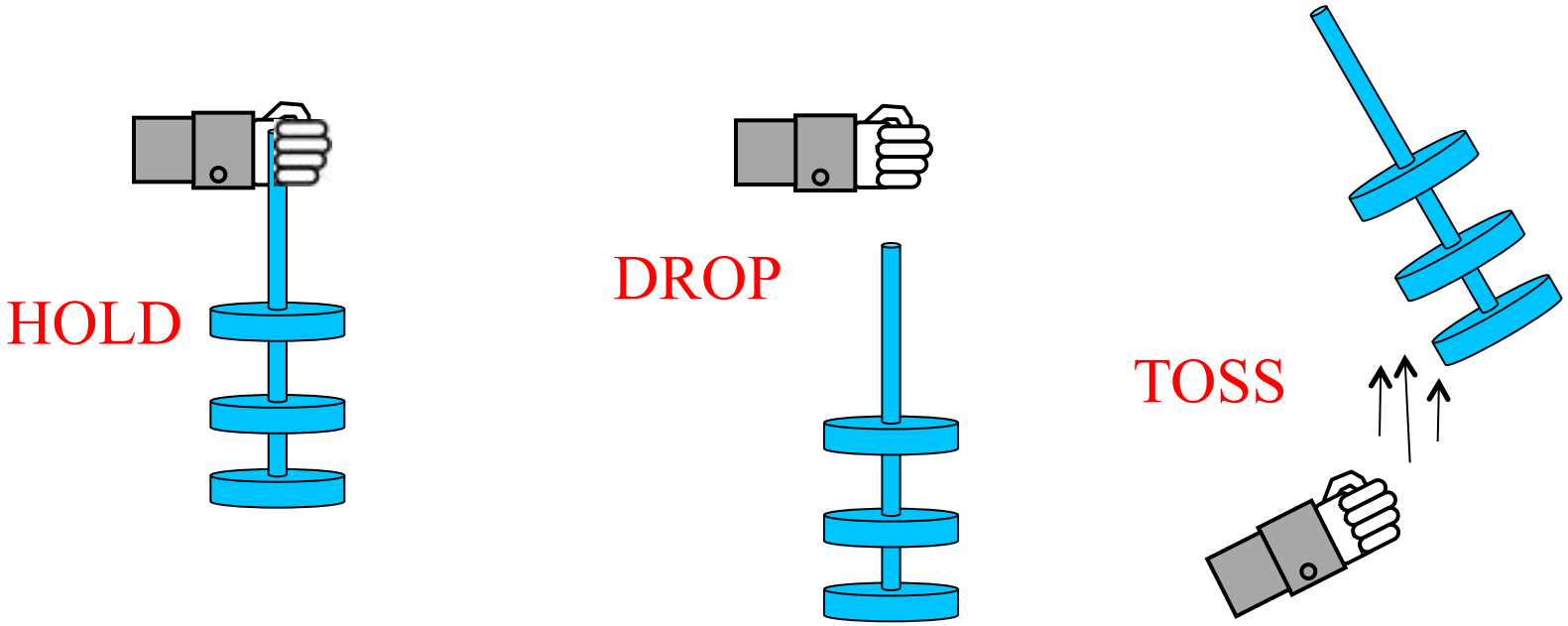
Astronaut in a bottle

- Hold the bottle by the neck and pinch string.
- Release just the string to let the astronaut fall inside the bottle. Observe action.
- Again, hold the bottle by the neck and pinch string, then release both to fall. Observe action.

WHAT FALLS? WHY? WHAT DOES THE ASTRONAUT DO INSIDE?

Magnet Shish-ka-bob

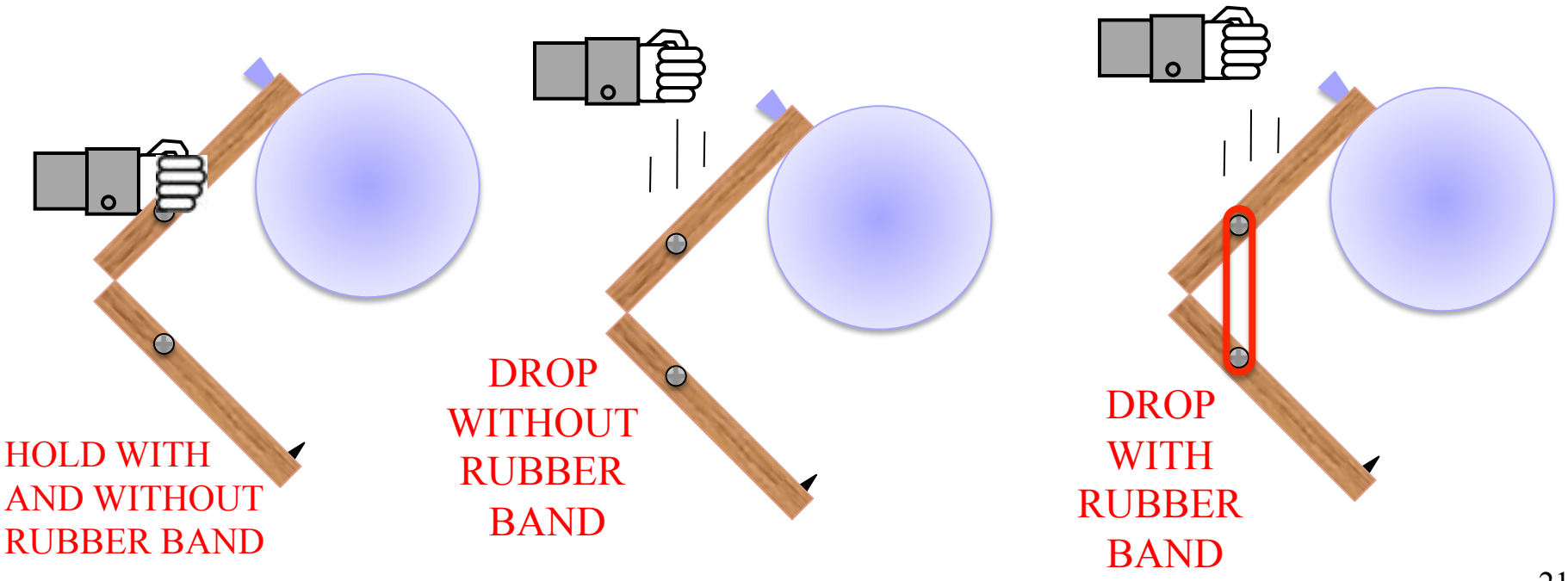
- Hold the rod by the top. Describe the magnet's positions. What forces are involved?
- Release the rod. Observe action of magnets.
- Cradle magnets and rod together in hand and then gently toss the rod and magnets up. Make sure you throw both the rod and magnets. Observe action of magnets.



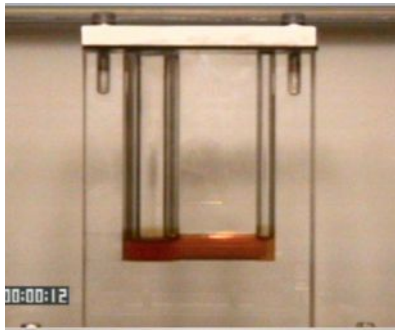
WHAT DO THE MAGNETS DO? WHY? (Neglect stick mass.)

Balloon popper

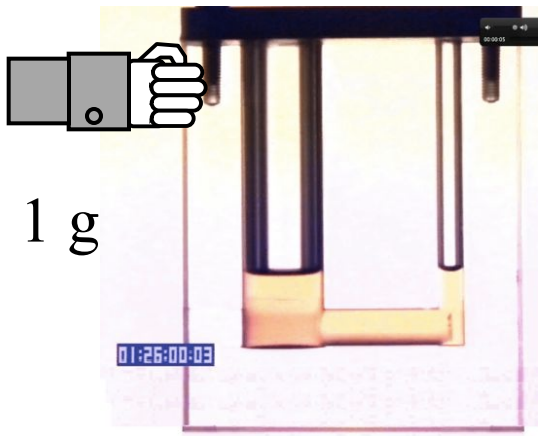
- Hold the balloon popper without a rubber band installed. What forces are involved?
- Release the balloon popper (*catch it before it hits the floor*). Observe action.
- Repeat those two steps WITH rubber band installed. What happens? Why?



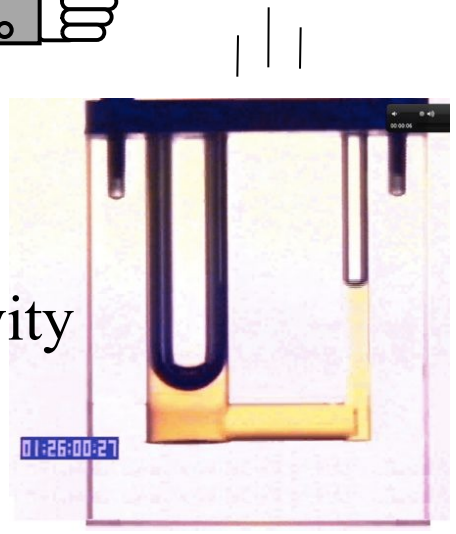
Oil-filled U-tube in mini drop tower



- The device is an oil-filled plastic chamber with two vertical cylindrical sections connected by horizontal tubes top and bottom.
- Oil is very ‘thin’ and ‘light’.
- What determines the shape when held in 1 g?
- What two major actions occoccur when it is falling?
- What forces are involved in 1 g and microgravity?



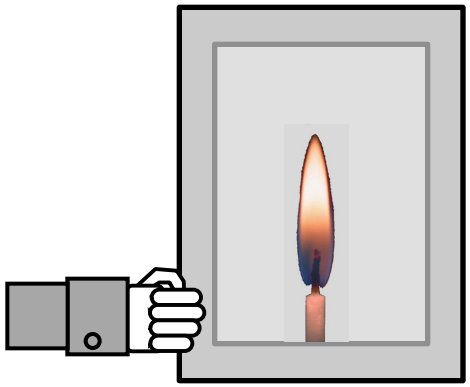
1 g



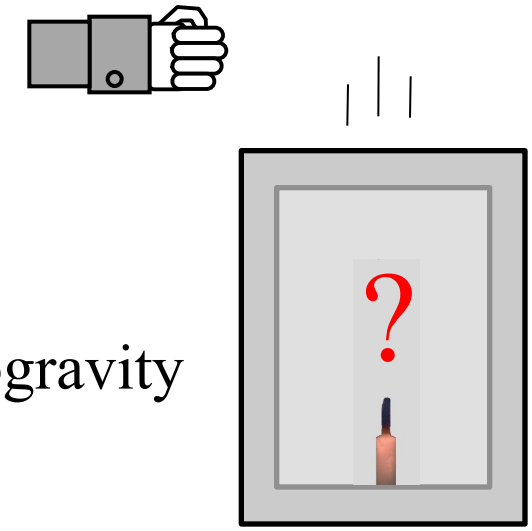
microgravity

Candle flame in mini drop tower

- A candle flame shape is affected by gravity.
- What determines the shape in a 1 g condition?
- What will such a flame do without effects of gravity?
- What shape does it assume when it is falling?
- What forces are involved in 1 g and microgravity?



1 g



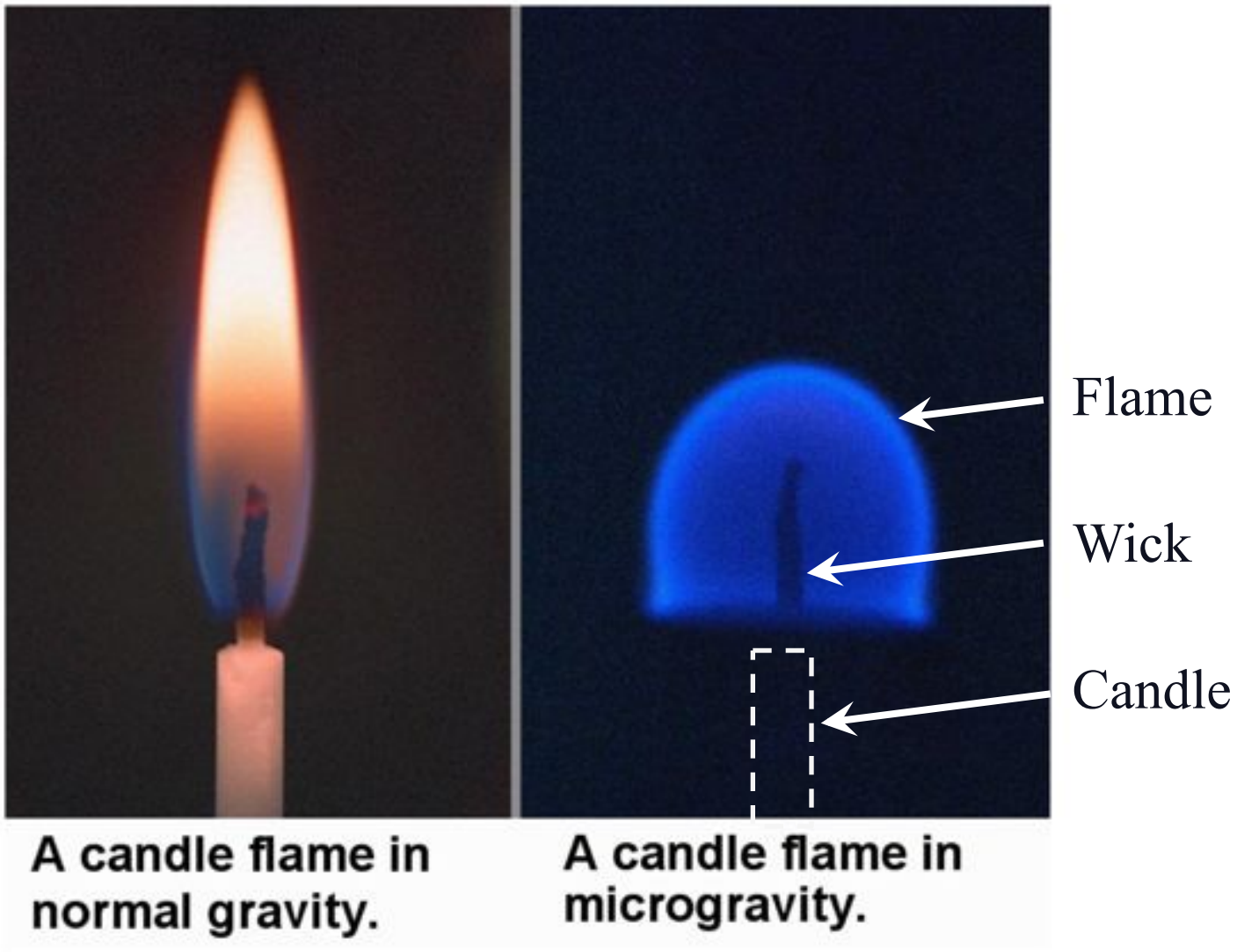
microgravity

Candle flame in 1 g

A candle flame in normal gravity.

A candle flame in microgravity.

Candle flames in 1 g and on Shuttle



Continue the fun next school year with the 2.2 Second Drop Tower at NASA Glenn

DIME and WING

Student Competitions
DIME & WING

- **DIME**
- **D**ropping **I**n a **M**icrogravity **E**nvironment
- High-school-aged student teams

- **WING**
- **W**hat **I**f **N**o **G**ravity?
- Student teams in grades 5 - 8

Student Competitions
DIME & WING

- Student team develops hypothesis & experiment concept
- Student team writes a **DIME** or **WING** experiment proposal and submits it according to the competition rules
- NASA staff evaluates all proposals according to published rubric
- NASA selects top **DIME** and **WING** proposals for teams to build their experiment

DIME & WING Student Competitions

- Selected **DIME** teams design, build, and test their experiments at home location.
- Four **Tier I DIME** teams receive trip to NASA Glenn Research Center during Drop Days in March to operate their experiment in the drop tower.
- Adult advisors of four **Tier II DIME** teams receive trip to NASA Glenn during Drop Days in March to operate their team's experiment in the drop tower.

- Selected **WING** teams design, build, and test their experiments at home location.
- All selected **WING** teams send their experiment to NASA for drop tower staff to operate in the drop tower.

DIME & WING Student Competitions

- All data from experiment operations are provided to the team
- Team members analyze the data and write a final project report

- End-to-end process by students similar to NASA and academic researchers in NASA programs
  - Hypothesis, proposal, review, design, fabricate, test, operate, and final report
  - Real science and engineering
  - Shorter time-frame, though, one school year instead of five or ten years

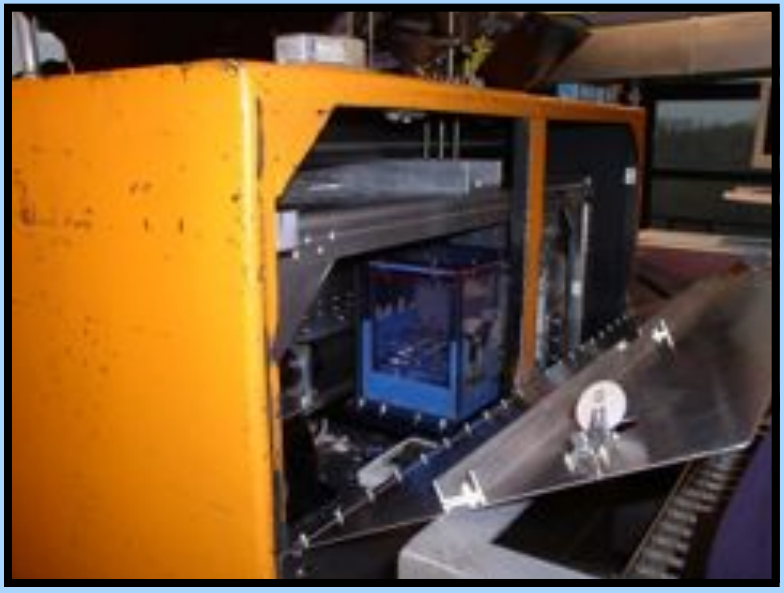
DIME & WING Student Competitions

- **DIME** & **WING** on-line information
  - Home page:
    `http://tinyurl.com/NASADIME`
  - YouTube page:
    `http://www.youtube.com/user/DIME10NASA`
  - Facebook page:
    `http://tinyurl.com/DIMEfacebook`

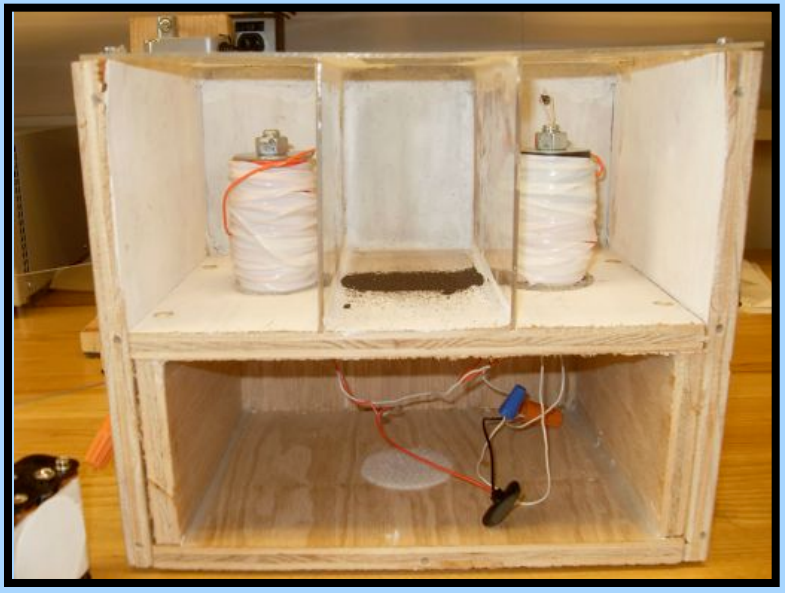


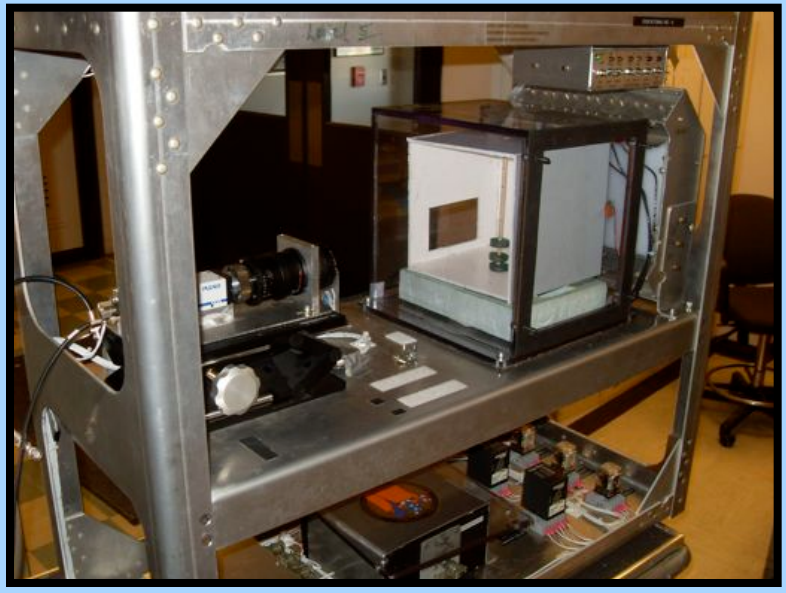
- Questions and comments for **DIME** & **WING**?
  - E-mail to: `dime@lists.nasa.gov`
  - Telephone: NASA Glenn 216-433-5643

Some past DIME teams



Example WING experiments





Summary

- Demonstrate microgravity in your classroom by dropping things!
- Analyze forces and motions in a gravitational field!
- Consider making a drop tower in your classroom!
- Consider advising a team for DIME or WING next year!
- Further resources on-line here:

  `spaceflightsystems.grc.nasa.gov/DIME_Documents/SEEC/2011.html`
  Or more simply: `http://tinyurl.com/SEECug-2011`

Further study!

- Students can use some of these topics to create science fair projects
  - *A Wisconsin middle school student did quite well in her science fair after I explained the leaky water bottle concept to her. She built an entire science fair project based on a plastic bottle with a hole, and got a superior!*
- Teachers might consider the ZERO-G Education Flights program

  `http://tinyurl.com/ZeroG-Ed`

Questions later?

- If you have questions or comments about this material, we want to hear about it!
- Please let us know how you use this material in your classroom!

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References and Additional Reading

Microgravity On-line Educator Resources

- Loads of free information on NASA web pages

  `http://education.nasa.gov/home/index.html`

- NASA Educational Materials

  `http://tinyurl.com/NASA-EduMaterial`

- What is Microgravity?

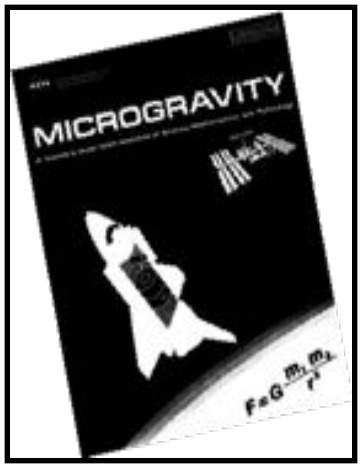
  `http://tinyurl.com/WhatIsUG`

- Microgravity Teachers Guide

  `http://tinyurl.com/MTGuide`

- NASA Space Place

  `http://tinyurl.com/SP-Orbits` (Orbital cannonballs!)
  `http://tinyurl.com/SP-ULaws` (Universal Laws)
  `http://tinyurl.com/SP-Kids` (Kids)



URLs can be case sensitive!
"G" is not "g" - be careful!

Microgravity Educator Resources - Additional Items -

- NASA educational products available for free
  - Contact a local NASA Educator Resource Center (ERC) from an on-line list:
  - `http://tinyurl.com/ListERC`
- NASA educational products available for a nominal fee ($$)
  - Central Operation of Resources for Educators (CORE) catalog has more than 200 NASA produced videocassette, slide, and CD-ROM programs available for a minimal charge.
  - `http://tinyurl.com/CORE-home`
- Informal Web Page of Amusement Park Physics products

  `http://tinyurl.com/APPD-info`
  - Acceleration match game for amusement park rides
  - NASA drop tower height comparison with amusement park rides
  - NASA microgravity aircraft comparison with roller coasters
  - Middle school teachers guide
    - *Amusement Park Physics with a NASA Twist*

Future Space Travelers

- Our lunar astronauts that will go to the **moon** have probably just graduated from college.
- Another generation of NASA's astronauts are in your classrooms now!
  - They probably don't realize their destiny!
  - Imagine if someone had told a 12-year old Neil Armstrong that he would not only walk on the moon, but he would be the first human to do so!
- The engineers and scientists that will help make those missions happen are sitting at desks next to those future astronauts.
- Please continue to inspire and motivate our future astronauts, engineers, and scientists!